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Biosystematics of gall aphids (Aphididae, Homoptera) of western Himalaya, India

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Abstract. Garhwal and Kumaun ranges of Himalaya include 250 odd species of aphids infesting a number of agricultural and forest plants. Out of these only 52 species (20%) are found to be gall formers. Majority of these gall aphids (63%) are indigenous. Except 4 species which produce true galls on stems, all other species are known to produce leaf fold or leaf roll or leaf base galls.

In general, the gall forming aphid species are heteroecious i.e. alternate between their primary and secondary hosts in different periods of the year. However, a few have been found to be autoecious i.e. monophagous. These aphids are also highly polymorphic in nature. Unless morphs from both of their primary and secondary hosts are available their identities in some cases are difficult. It has been observed that the morphology of aphid galls, karyomorphology, host association, life cycle pattern and natural enemies (both predators and parasites) help in the identity of such aphids more precisely, particularly in the closely related species complexes.

Keywords. Gall aphids; gall formation; gall morphology; Life cycle; host association; cytogenetics; predators; parasites; Western Himalaya.

1. Introduction

Aphids or plant lice, a homopteran insect group occupy a special status among the plant pests particularly due to their special mode of reproduction. They damage the plants directly through sucking up of the plant sap and there by inflicting several symptoms on the plant surface of which plant galls are very important. Among the indirect damages the role of aphids as vectors of several plant viral diseases received world wide importance (Eastop 1977).

Aphids although are predominant in the temperate regions (Dixon 1984) have a world wide distribution except Greenideinae and Hormaphidinae that make up about 7% of the world fauna and now restricted to South East Asia and America. A total of 3742 species of aphids are known (Eastop and Hille Ris Lambers 1976) from the world. From the list of Agarwala and Ghosh (1984) and also from further accounts, published during 1982 to 1986, a total of 691 species are now known from India which constitutes at least 15% of world fauna.

Available records show the preponderance of aphid fauna in the mountains of India, particularly in the Himalayan regions. Several papers relating to distribution of aphids in different regions of India (Agarwala 1986; Agarwala and Ghosh 1985; Chakrabarti 1983; Ghosh 1983, 1986; Ghosh and Raychaudhuri 1980; Maity *et al* 1983; Saha and Raychaudhuri 1986) also emphasised the host-aphid relationships. Aphids, one of the major gall forming insect groups, however, received very little attention in the Indian context.

So the scope of this paper is limited on the Biosystematics of gall forming aphids

of Western or Kumaun-Garhwal Himalaya. This part of Himalaya lying between the Central or Nepal Himalaya and North west or Punjab Himalaya received special attention for aphidological studies in recent times. To avoid duplications of the recent review on the biology of gall aphids (Wool 1984) discussions were restricted on the species or related species found in the area. However, for general understanding mention of a few species not found in the area could not have been avoided.

2. Fauna of the area

Through the works of Chakrabarti (1972), Maity (1979), Saha (1986) and also through several stray reports about 250 odd species are known from the area. This includes several species infesting agricultural and forest plants where they sometimes inflict specific damage symptoms in the form of galls.

2.1 *Taxonomy of gall aphids*

The association of aphids with true galls on host plants is considered a primitive one. Among the 52 gall forming species known from the area (table 1) of the superfamily Aphidoidea, all belong to the family Aphididae. The other 2 families viz Adelgidae and Phylloxeridae although known by gall forming species in other places, are not represented in the area. Galls of Aphididae belong to 3 subfamilies viz Pemphiginae, Aphidinae and Hormaphidinae.

Taxonomy of gall forming species is very much complicated for several reasons viz complex life history, extreme morphological variations in different polymorphic forms, different host associations etc. Knowledge of taxonomy of these aphids remain incomplete unless and until several phenomena like host association, gall morphology, life cycle and biology in general are worked out and employed along with morphology of aphids for their identification. Besides, some other tools like karyomorphology, biochemical studies (isoenzymes, gall biochemistry etc), natural enemies also may further help in their identification. The state of our such knowledge on gall forming aphids of western Himalaya are also highlighted.

3. Gall formation and gall aphid

It is very difficult to define a gall particularly an aphid gall. A gall is formed due to interaction between the offensive stimuli involving growth substances released by insects and the defensive response by plants (Rosenthal and Janzen 1979). Although the precise mechanism of gall formation is not yet known, but plant growth hormone IAA (either transmitted with the saliva or formed in the plant by oxidative transamination of tryptophan by saliva enzymes) and free amino acid in the saliva is suspected for cecidogenesis (Miles 1968, 1972). The specific response of the plant is the result of an altered metabolism due to the action of an alien chemical stimulus together with the wounding effects as a result of feeding or oviposition inducing alternation in the cellular and metabolic environment initially around the feeding area. Different kinds of tissue reorganisation including the major cecidogenic phenomena like hypertrophy and hyperplasia ensue leading to gall formation (Ananthakrishnan 1984). Gall formation is a complex phenomena involving the

recanalisation and reorientation of plant development and such growth activities result in the insects becoming partially or completely enclosed, so that gall insects grow, mature and reproduce within the galls (Ananthakrishnan 1984). Insect galls have limited neoplasm and thus continue to develop only so long as the cecidogenia is associated or its immediate metabolic products are present in the tissue (Mani 1973). The responsibility of gall initiation in aphids lies with the fundatrices. In Pemphiginae single fundatrix may initiate a gall. The first instar nymph of fundatrix having stout fore legs in *Epipemphigus niisimae* (Aoki and Makino 1982) initiates gall on the leaves of poplars in Japan. During such activities, other first instar nymphs and/or later stage of nymphs may invade the partially formed galls when a strong resistance and fighting between the gall inhabitant and the intruding individuals are noticed. In western Himalaya similar phenomenon was observed in *Epipemphigus imaicus* while the first instars of this species were initiating galls on the leaves of *Populus ciliata* (Chakrabarti S, unpublished results). Feeding of several nymphs may sometimes be required for the development of galls in *Salvum werlheime* (Wertheim and Linder 1961) and in *Mordwilkoja vagabunda* (Ignoffo and Granovsky 1961). Two different types of galls on *Pistacia atlantica* are formed by the fundatrices and the apterous offsprings of some Fordini (Koach and Wool 1977; Wertheim 1954) and in *Thecabius populimonalis* (Maxson and Knowlton 1929). Similarly, coloured caterpillar galls and leaf fold galls are produced by *Eumyzus prunicolus* in western Himalaya.

Though the tendency to produce disorganised growth and malformation in plants is common, true galls are always positive, directional responses resulting in disharmonic growth effects with the polarity related to the insect rather than the rest of the plants (Ananthakrishnan 1978).

The classification of aphid galls is rather conflicting. Many species cause leaf deformation in a definite pattern on specific host and sometimes all the individuals of the colony can not be covered within such deformations. In the literature these structures are referred to as leaf galls, leaf roll galls, pouch galls, curl galls etc and more commonly as pseudogalls. The other forms which completely cover gall forming individuals are true galls. Here, both these types have been taken into consideration.

Only 12 pemphigine species form true galls on stem, leaves and petioles and the remaining species under this subfamily and all other species under subfamilies Aphidinae and Hormaphidinae form leaf roll, leaf fold, leaf curl galls etc.

4. Endemism

Quite a large number of aphids are endemic. Except *Epipemphigus* which is also found in Pakistan, no other gall aphid genus is truly endemic. But as many as 24 species (46%) are endemic.

5. Life cycle

Wool (1984) discussed the available information on the life cycle of gall aphids. These informations do not contain any biological peculiarities of many species occurring in India, particularly in western Himalaya.

The pattern of life cycle is unique and highly adapted for individual species with a view to reproduce successfully, to tide over some adverse conditions and to avail of the maximum chances of security for survival. Gall aphids are in general host alternating (heteroecious) and represented by both parthenogenetic and sexual cycles (holocyclic). This general or primitive pattern is still maintained in several species. Chakrabarti *et al* (1985) provided some accounts of the life cycle pattern of Pemphigine species infesting poplar in western Himalaya. The typical heteroecious holocycle in Pemphiginae has been found modified in several species of the genera *Baizongia*, *Forda*, *Geoica*, *Pemphigus* and *Thecabius*. Perhaps the typical condition is maintained in the species of *Epipemphigus*, *Eriosoma*, *Kaltenbachiella*, *Prociphilus* and *Tetraneura*.

Several adaptive strategies are found in the species of *Pemphigus* in the area. Apterous viviparous generation is missing (suppressed) in *Pemphigus dorocola*, *P. matsumurai* and *P. mordvilkoi*. Ghosh (1984) following Maity and Chakrabarti (1981) wrongly mentioned the presence of apterous viviparous generation in *P. mordvilkoi*. However, this generation is always present in *P. siphunculatus*. At least 3 species of *Pemphigus* viz *dorocola*, *mordvilkoi* and *siphunculatus* lead autoecious life on poplars (figure 1). Fundatrices in these 3 species have a long life and are found till the end of autumn and the sexuparae are produced within the galls and can be located there till the advent of winter. At least in *mordvilkoi*, sexuparae hibernate in winter and sexuals are laid in early spring (Chakrabarti S and Mandal A K, unpublished results). The gall forming generations on *Pistacia integerrima* by the species of *Baizongia*, *Forda* and *Geoica* of the tribe Fordini are of very short duration. These aphids lead a 2-year cycle (figure 2). After completing one full year and also the summer months of the second year on the secondary hosts, alate immigrants (sexuparae) are produced which migrate to *P. integerrima* for laying sexuals and ultimately hibernating eggs. The fundatrices are produced from these eggs in spring which initiate specific galls where they live upto first half of the summer months only then they again migrate to their secondary hosts (Hille Ris Lambers 1957; Wertheim 1954; Bodenheimer and Swirski 1957). There is also a possibility that some species partially adopted anholocyclic life as found in Australia, Central and Northern

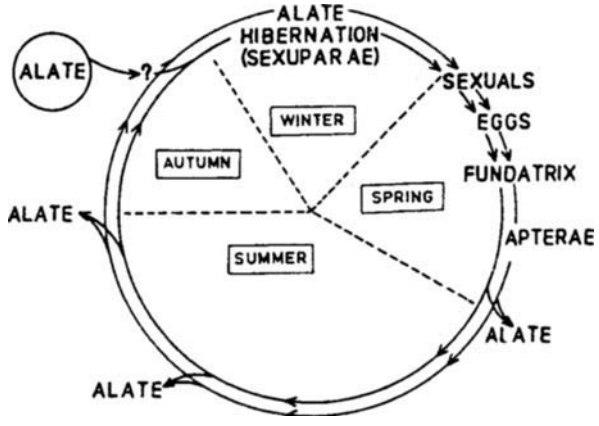

Figure 1. Autoecious life cycle pattern in some *Pemphigus* species in Western Himalaya.

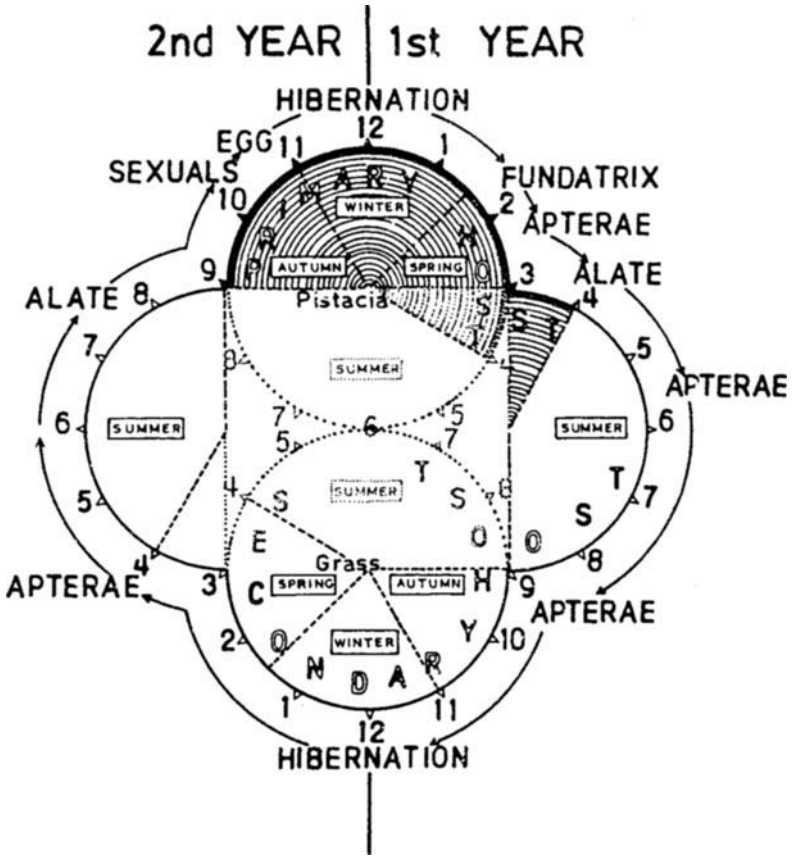

Figure 2. Two-year life cycle pattern of *Forda marginata* in western Himalaya.

Europe and in America (Hille Ris Lambers 1970). *Eriosoma* species except *E. lanigerum* alternate between species of elm (*Ulmus* spp.) and roots of Rosaceae particularly *Ribes* spp. The apple wooly aphid, *E. lanigerum* leads heteroecious holocyclic life on *Malus* spp., *Pyrus* spp. and *Ulmus* spp. in North America (Danielsson 1979; Smith 1985) and anholocyclic life on *Pyrus* spp. and *Malus* spp. in Israel and Denmark (Heie 1980) and an abortive gamic cycle at least in Switzerland. In western and north west Himalaya this species leads autoecious anholocyclic life on its secondary hosts, *Malus* and *Pyrus* spp. where it hibernates in roots and cracks and crevices of stem of the plants. In India this species sometimes produces sexuals (Fotedaer and Kapur 1943) which seem to be abortive. A similar condition is observed in *Thecabius affinis* which produces galls on *Rananculus hirtellus*, a secondary host in other countries (Mordvilko 1934; Tullgren 1909; Danielsson 1979). In western Himalaya *Geranium wallichianum* and *Geranium* spp. are the secondary hosts of this species where it lives on roots. This species has never been collected on poplar in India. Species of *Tetraneura* alternate between *Ulmus* spp. (primary hosts) and grasses (secondary hosts). However, the possibility of anholocyclic life like the species of Fordini viz *T. nigriabdominallis* and *T. radicicola* can not be over ruled since these species also occur even at very low altitudes where its primary host does not grow. *Prociphilus* spp. has

Lonicera, *Syringa* and *Cotoneaster* as their primary hosts. Only *P. himalayaensis* has been collected from its secondary host, *Pinus wallichiana* where the species lives on its roots. The morphological similarities demands the correlation of *P. taxus* described from the roots of *Taxus baccata* (secondary host) with the material received from *Syringa emodi* (primary hosts) through transfer experiments. *Kaltenbachiella pallida* is heteroecious but details of its life cycle is not known.

Among the Hormaphidine species *Hamamelistes miyabei* produces leaf galls on *Betula alnoides* and *Betula utilis*. Species under this genus in other countries alternate between *Betula* and *Hamameleis*. *H. spinosus* produces galls on flower buds, hibernate on birch for a longer period and cannot complete the entire cycle within one year (Ghosh 1985; Pergande 1901). In western Himalaya, *H. miyabei* was found on *Betula* till June and further information on its life cycle is lacking. In general, members of Nipponaphidini produce galls on its primary host *Distylium*, *Hormaphidini* on *Hamamaleis* and Ceratiphidini on *Styrax* (Sorin 1966). Several changes in the life cycle pattern leading to anholocyclic monophagism either on its primary host or on its secondary host have been found in this group. Several species of the genera *Astegopteryx*, *Cerataphis*, *Ceratovacunna*, *Chaitoregma*, *Heminipponaphis*, *Indoregma*, *Neothoracaphis*, *Pseudothoracaphis* and *Tuberoaphis* lead autoecious anholocyclic life on their secondary hosts in the area.

In subfamily Aphidinae, gall formers are mainly restricted to two genera viz *Eumyzus* and *Myzus* where 10 species produce galls. Other important gall producing genera are *Aphis*, *Avicennina*, *Brachycaudus*, *Cryptaphis* and *Dysaphis*. All these species are heteroecious and possibly holocyclic. Alate males are produced on secondary hosts in several species. Number of generations, both on primary and secondary hosts are variable even in closely related species of *Myzus*. Many of these species have several secondary hosts and some of them may be designated as summer reservoir. Peach leaf curling aphid, *Brachycaudus helichrysi* has atleast 20 secondary hosts.

6. Host aphid association

6.1 *Host specificity*

Gall forming aphids are impressively host specific on their primary host. Each family or subfamily or tribe is usually restricted on single plant family or genus. Secondary hosts of many groups may however, also be specific or at least belong to the same plant family. The host association and host alternation is more specific and rigid in Pemphiginae than in any other groups. In Aphidinae, *Prunus* spp. serves as the primary host of several species of *Avicennina*, *Brachycaudus*, *Eumyzus* and *Myzus*.

The polyphagy particularly in Pemphiginae in many cases, turns out to be the result of morphological similarity of genetically different strains or races of aphids adapted to morphologically similar but genetically distinct races of host plants (Wool 1984). It has been found that in Pakistan, *Populus niger* and *P. euramericana*, a hybrid from the cross of European *P. nigra* and American *P. deltoides*, growing side by side but only the former plant is heavily infested by *Pemphigus lichtensteini*, while the latter remains uninfested (Habib and Ghani 1970). A similar hybrid developed from *P. ciliata* and now growing in and around Joshimath also shows resistance to

Epipemphigus imaicus and *Pemphigus mordvilkoi* infestation. During late autumn or early winter sexuparae were found to settle in the cracks and crevices of these hybrid plants but fail to initiate galls on them in the next spring. But the nearby wild plants of *P. ciliata* are always nearly infested. A similar case was also found in America (Grigarick and Lange 1968). Whether a plant will or will not be successfully colonised by aphids may depend on physiological, nutritional, ecological or genetical factors of both aphids and host plants.

6.2 *New host acquisition*

A few new host acquisitions have also been found in the area. *Pistacia* is the primary host of Fordini where these aphids produce galls. But at an altitude below 100 m *Pistacia* does not grow and *Forda orientalis* accepts *Toona ciliata* (Meliaceae) as its primary host where it produces leaf marginal galls. *T. affinis* produces leaf galls on *Ranunculus hirtellus* instead of *Populus*. The former is the secondary host of this species. *Geranium* spp. serve as the secondary host of this species in western Himalaya.

6.3 *Gall morphology*

The shape and size of aphid gall in general are extremely variable (Ghosh *et al* 1981; Bhattacharya 1982). Inspite of such diversities, gall of a particular species is very specific and helpful for identifying especially some pemphigid species which are very laborious to separate morphotaxonomically (Chakrabarti S and Mandal A K, unpublished results). *Eriosoma kashmiricum* and *Eriosoma* sp. are hardly separable by morphological characters but very distinct in gall morphology. In comparison to pemphigids, other galls are less specific in their morphology (table 1). Colour of galls, particularly in *E. imaicus*, *Eumyzus pruni*, *E. prunicolus*, *Forda marginata*, *Geoica urticularia* and *Pemphigus matsumurai* are quite distinct. Conical galls, characteristic of *Tetraneura* species on *Ulmus* spp. are more in number on individual leaf in *T. (Indotetraneura) javensis* but a few per leaf in other *Tetraneura* species. Other leaf gall characteristics of different genera are globular hard leaf base galls of *Kaltenbachiella pallida*, cystolith shaped leaf base galls of *P. matsumurai*, caterpillar galls of *E. imaicus*, globular basal galls of *G. urticularia*. Galls of *Baizongia pistaciae* on *Pistacia integerrima* are unique in having an elongate structure developed from leaf buds or axils. Leaf spiral galls of *Eriosoma* on *Ulmus* spp. and leaf fold galls of *Prociphilus* on *Lonicera* and *Syringa* are hardly separable by their structures but have some specificity with regard to the time of occurrence.

Galls of Aphidinae, when considered irrespective of their host plants are hardly separable. But on *Prunus*, species of several genera (table 1) are found but those of *Avicenenna indica*, *E. pruni* and *E. prunicolus* maintain their identities.

7. Cytogenetical studies

Cytogenetics of aphids have several fascinating chapters. But almost all works on gall aphids in India is restricted so far on the karyomorphology of parthenogenetic viviparous morphs. As many as 685 world aphid species are known (Blackman 1980,

Table 1. Gall aphids and their host plants, nature of galls and chromosome number in western Himalaya.

Aphid species	Host plant (primary)	Gall type	Chromosome number (2n=)
Subfamily: APHIDINAE			
Aphis clematidis	*Clematis buchaniana*	Leaf curl	
A. fabae	*Solanum nigrum*	Leaf curl	
A. gossypii	*Cuminis* sp.	Leaf curl	6, 8
Avicenenna indica	*Prunus cornuta*	Leaf fold	
Brachycaudus helichrysi	*Prunus amygdalus*	Leaf curl	11, 12
	P. domestica	Leaf curl	13
	P. persica	Leaf curl	
Ceruraphis eastopi	*Viburnum cotinifolium*	Leaf fold	
Cryptaphis garhwalensis	*Lamium album*	Leaf curl	
Eoessigia indica	*Cotoneaster obtusus*	Leaf curl	
Eumyzus eastopi	*Pyrus vestita*	Leaf roll	
E. hydrangi	*Hydrangea scandens*	Leaf fold	
E. impatiensae	*Impatiens* sp.	Leaf fold	
E. pruni	*Prunus cornuta*	Leaf marginal	
E. prunicolus	*P. cornuta*	Leaf fold and caterpillar	
Dysaphis sp.	*Cladeolus* sp.	Leaf fold	
Dysaphis sp.	*Pyrus vestita*	Leaf roll	
Hayhurstia atriplicis	*Chenopodium album*	Leaf fold	14
Hyalopterus pruni	*Prunus cornuta*	Leaf curl	10
Myzus cornutus	*Prunus cornuta*		
Myzus formosanus	*Polygonum capitatum*	Leaf roll	12
M. mumicola	*Prunus* sp.	Leaf roll	
M. ornatus	*Prunus* sp.	Leaf roll	12
M. persicae	*Callicarpa* sp.	Leaf fold	10, 11, 12, 13, 14
M. sorbi	*Sorberia tomentosa*	Leaf roll and leaf curl	12
Rhopalosiphoninus ehretis	*Schizandra grandiflora*	Leaf	
Sappaphis sp.	*Cotoneaster obtusus*	Leaf roll	
Tubicauda hydrange	*Hydrangea* sp.	Leaf roll	
Subfamily: HORMAPHIDINAE			
Hamamelistes miyabei	*Betula alnoides*	Leaf fold	
Tuberaphis loranthi	*Loranthus cordifolius*	Leaf roll	
Subfamily: PEMPHIGINAE			
Baizongia pistaciae	*Pistacia integerrima*	Elongate	24
Epipemphigus imaicus	*Populus ciliata*	Caterpillar	18
Eriosoma sp.	*Ulmus laveagata*	Leaf base	
Eriosoma kashmiricum	*Ulmus* sp.	Leaf spiral	12
E. lanigerum	*Pyrus malus*	Leaf fold	12
E. phaenax	*Ulmus montanus*	Leaf spiral	
E. ulmi	*Ulmus* sp.	Leaf spiral	12
Forda marginata	*Pistacia integerimma*	Leaf marginal	24, 25, 26, 27, 28, 32
F. riccibоni	*Pistacia integerrima*	Leaf marginal	18
F. orientalis	*Toona ciliata*	Leaf marginal	
Geoica urticularia	*Pistacia integerrima*	Globular leaf base	
Kaltenbachiella pallida	*Ulmus* sp.	Leaf base	28
Pemphigus dorocola	*Populus ciliata*	Stem gall	20
P. matsumurai	*P. ciliata*	Leaf base	12

Table 1. *(Contd.)*

Aphid species	Host plant (primary)	Gall type	Chromosome number (2n=)
P. mordvilkoi	*P. ciliata*	Stem gall	
P. siphunculatus	*P. ciliata*	Stem gall	
Prociphilus sp. A.	*Syringa emodi*	Leaf curl	10
Prociphilus sp. B.	*Lonicera quinculocularis*	Leaf fold	
Prociphilus sp. C.	*Cotoneaster* sp.	Leaf fold	
Prociphilus himalayensis	*Lonicera quinculocularis*	Leaf fold	
Tetraneura javensis	*Ulmus* sp.	Leaf conical	
T. nigriabdominalis	*Ulmus* sp.	Leaf conical	12, 14, 22, 24, 26
T. ulmi	*Ulmus* sp.	Leaf conical	
Thecabius affinis	*Ranunculus hirtellus*	Leaf fold	38

1986; Kuznetsova and Shaposnikov 1973; Kurl 1986). Chromosome number does not suggest an ancestral number for Aphididae (Blackman 1980).

In India karyotypic analysis has been made in some 80 odd species and chromosome formulae based on relative percentage length of individual chromosome pairs have been ascribed for some 35 species (Khuda-Bukhsh 1986). Variations in chromosome number and structural heterozygosity have been noticed. Chromosome number of only 21 gall forming species are known (table 1).

Since gall forming genera and species are almost always with a sexual phase, they represent more stable karyotype. In several genera differences in gross chromosome morphology can be useful to the taxonomists. Within species karyotype variation is relatively common in aphids and instances on structural heterozygosity are particularly numerous in species and groups which have partially or completely abandoned the sexual phase of thelotoky (Blackman 1980). Thus heterozygosity are found in *B. pistaceae*, *B. helichrysi*, *F. marginata*, *Myzus persicae*, where partial or complete anholocycly are found.

Karyotypic studies of closely related genera, species, host alternating species, polymorphic and polyphagous species in different geographical areas (clones) may provide some clue for better identification or rather confirmation of specific identification.

8. Natural enemies

Galls provide a natural protective environment to the individual insect. Adaptive strategies of natural enemies to get into the galls, particularly true galls are very important for their effectiveness. A number of predators and parasites are associated with the gall aphids. Normally the association of predators with the leaf fold and leaf roll galls are heterogeneous, while the parasitic complexes are more specific both in the true galls and pseudo-galls.

8.1 *Predators*

Major predatory complexes are coccinellids, anthocorids, syrphyids and neuropterans. As many as 16 coccinellid species are found (Ghosh D, Debnath N and Chakrabarti S, unpublished results). Only *Halyzia sanscrita*, *Harmonia eucharis*, *Harmonia (Leis) dimidiata* and *Menochilus sexmaculatus* can predate on the true pemphigid gall

aphids. Individual leaf roll or fold gall aphid receive quite a large number of heterogeneous coccinellids and thus *E. lanigerum* have at least 11 coccinellid predators. *Coccinella setempunctata* and *H. eucharis* each have 7 gall aphid prey species while *Adalia tetraspilota* and *Oenopia sauzeti* have 6 and 5 prey aphids respectively. Hodek (1973) questioned the aphidophagous habit of *Platynaspis saundarsi*, which is found to predate *Eriosoma lanigerum* and *Sappaphis* sp. in the area. Similarly, *Halyzia sanscrita*, a mycophagous species exhibits aphidophagous nature in western Himalaya.

Anthocorids are more active and due to their small body size they can easily enter into the galls. At least 7 species are found with gall aphids (Ghosh D, Debnath N and Chakrabarti S, unpublished results). Only *Anthocoris confusus*, *A. flavipes*, *Orius niger* and *Ectemnus* sp. are found within the true galls. Another hemipteran predator, *Deraeocoris* sp. (Miridae) is associated with *Pemphigus mordvilkoi*.

Syrphyid larvae of 8 species (Ghosh D, Debnath N and Chakrabarti S, 1985) although very active on leaf fold or roll gall have not been found within the close galls except *E. imaicus* where *Episyrphus balteatus* and *Metasyrphus confrater* were recorded. These larvae were found only in the latter part of the gall life of aphids when the rim margin of the galls become loose and alate imigrants are ready for migration. The sluggish nature of syrphyid larvae and their large size generally prevents their entry into true galls. Aoki (1978) observed some syrphyid adults to lay eggs near the opening of the galls of *P. dorocola* so that the larvae immediately after their emergence can enter into the galls. No such incidence was observed in the area.

Neuropterans are less active on the gall aphids and only *Cunctochrysa jublngensis* larvae were found within the stem galls of *P. mordvilkoi*. Other predatory complexes are mites of the genera *Anystes*, *Podothombium*, *Allothrombium*, *Dinothrombium*, *Enemothrobium*, *Abrolophus*, *Balaustium*, *Paraerythaeus* sp. The chamaemyiid larvae *Leucopis* spp. are very common in both close and pseudogalls. An earwig, *Forficula beltzebula* was found within the stem galls of *P. mordvilkoi* and *P. dorocola* where the galls were completely cleaned. Whether this insect really predates on these aphids or takes only shelter has to be confirmed. Several spiders are also found with the gall aphids.

8.2 *Parasites*

Aphidiid parasites of 10 species under the genera *Aphidius*, *Diaeretiella*, *Ephedrus*, *Kashmiria* and *Trioxys* are found on gall aphids. Except *Ephedrus srinagarensis* and *Kashmiria aphidis* which are restricted on *Prociphilus* spp. all other species are polyphagous. No aphidiid parasite is found on the aphids producing true galls. Although aphidiid parasites try to avoid wax of the aphid colony (Stary 1970) *K. aphidis* is found to cover themselves with wax material present within the gall colony of *Prociphilus* spp. (Das and Chakrabarti 1986).

Several hymenopteran parasites of the family Encyrtidae, Eulophidae, Figitidae, Pheromatidae and Ichneumonidae are found to parasitise the syrphid predators of gall aphids. Hyperparasites of Aphidiid parasites under the family Cynipidae, Encyrtidae, Pteromalidae and Magaspilidae are quite common in the later part of parasitic infestation.

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